Integration of Heterogeneous Cultural Heritage Data in a Web-based Information System: A Case Study from Vianden Castle, Luxembourg

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Abstract

The project presented here proposes the first implementation of a Web-based Information System for the conservation, handling, and use of site data. The case study is the castle of Vianden in Luxembourg, on which considerable archaeological data have accumulated over the years. There is a recognized need in archaeology for a tool that will allow for fast, effective, and flexible exploratory analysis of data, especially at spatial and temporal levels. We have developed such an Information System with maximal portability by using Extensible Markup Language (XML) and Extensible Stylesheet Language (XSL) for data exchange. Our system consists of several interfaces permitting different types of access to heterogeneous information. We propose a description of the data in textual interfaces along with images, and dynamic links to this data through interactive 2D and 3D representations. The 2D images, photos, or vectors are generated in Scalable Vector Graphics (SVG), while 3D models are generated in X3D.

1 Introduction

Cultural heritage documentation induces the use of computerized techniques to manage and preserve the information produced. In the archaeological domain particularly, data computerization gives solutions to specific problems in allowing inventory actions to save, present, or interpret the features. Archaeology is an erudition discipline where the knowledge grows through the necessary referencing of the precious documents gathered. Computer science has fast appeared as a very convenient way to manage this huge quantity of information. Moreover, there is primary information, concerning the archaeological realities themselves (objects, configurations, etc.), and secondary information, regarding the documents that enable one to know these realities, as well as publications with artifact descriptions and comments, or images collections. Therefore, it is necessary to develop systems that allow one to create relationships between this information; for instance, for a primary data item like an inscription, to retrieve instantly the diverse secondary data that facilitate its study.

We are developing such a tool for the management of documents generated by the work at an archaeological site. We have chosen to work at the scale of a site because there are more completed projects at regional or national levels, and these mostly use Geographic Information Systems (GIS), whereas we are creating an Information System permitting the management of very different types of data (not only geographical), which are more uncommon. In addition, we dedicate our system both to the professionals who are in charge of the site and to the general public who visits it or who wants to have information on it. Hence, we are using open source software modules and languages dedicated to the Internet to develop our Web Information System, in order to be software independent and to allow maximum accessibility and adaptability to the needs of the diverse users of the tool. Our first application case is the medieval castle of Vianden, which is located in Luxembourg.

This project falls within the context of research conducted as part of a PhD thesis (Meyer 2007). It is managed in laboratories of the group MAP (Modeling and Simulation for Architecture, Urbanism and Landscape), UMR CNRS 694, France, of which one research axis is *Digital tools and cultural heritage*. The system notably combines survey, modeling, and restituted data, and our purpose is to highlight the degree to which such a system can help to achieve the complete documentation of archaeological sites. First, we will underline and explain the increasing role of computer science in the context of cultural heritage management. Our reflection is based on a synthetic paper written by Julian D. Richards (1998): *Recent trends in computer applications in archaeology* Next, the first implementation of the tool that we are developing will be presented. We will describe the types of data managed by the system and how it is recorded in a database. Then, we will show means to access these data: through queries and through 2D and 3D interactive representations. Finally, we will explain the methods for updating and revising the data for the experts working on the site.

2 Cultural Heritage Management and Computer Science

A good overview on this subject has been given by Richards (1998) who argues the use of computer science in archaeology is often driven by available software rather than by archaeological questions. This is a problem to which we will propose solutions. Five main groups of computer techniques can be derived from the study of Richards: databases, GIS, visualization, artificial intelligence, and education/communication. We will provide details for some of these techniques in order to explain the choices made during the development of our tool.

2.1 Databases

At the beginning (1960), databases were founded on statistical approaches, significance testing, and multivariate analysis. Then, discussions about database design dominated the debate (Guimier-Sorbets 1990; Ginouvès 1990). The principal questions of concern involved the generalization and the standardization of the databases in order to avoid constraining rather than helping researchers. Likewise, there are practical and theoretical difficulties concerning the nature of very heterogeneous data. In any case, it is necessary to plan, from the beginning of the work, the possibility of connection between different databases. Regarding database content, it was proposed (Ginouvès and Guimier-Sorbets 1978) to record the totality of the characteristics generally used by the archaeologist in his interpretative reasoning, along with additional access to ancillary data that may allow a more precise view of the item or document, or for which there may one day be value. Therefore, the description of the document that is recorded in the database is at least as rich as the report from traditional publications. From a practical point of view, it is even richer because the totality of the provided information is recorded, whereas traditional publication makes various non-explicit choices. These recommendations are still current and the recording of metadata (data about data) is common nowadays, notably with the Extensible Markup Language (XML) format.

During the 1990s, archaeological interest has focused "on how the structure of excavation data can be successfully modeled in a relational database, on the possibilities of object-oriented design, and on the creation of databases founded upon archaeological entities" (Richards 1998:333). These steps were necessary to grasp the way to define the relationships between the archaeological features recorded in the database tables and to consider objects for what they do, and not just for what they are. Then, the classic excavation databases were adapted to be able to link computer-aided design objects or context data. The idea is that an excavation archive can be viewed as a hyper document with texts and images bounded by internal links and allowing readers to follow different paths to retrieve information through the report (Ryan 1995). And "if such documents can be made publicly accessible, over the Internet, for example, then they begin to blur the distinction between archive and publication" (Richards 1998:335). Our work has been carried out this way). Examples of integrated computerized field project linking basic finds, plans, and context data recording in the field and operated using GIS mapping tools are related in Powlesland (1991) and Cosmas et al. (2001).

A drawback of projects carried out currently is the fact that a large proportion of the literature until now has been concerned with the establishment of databases of archaeological sites and monuments at regional and national levels for cultural resource management purposes. There are few projects concerning data management at a site level, the data recorded obligated to being dissimilar at this scale than at a bigger scale. Consequently, our project is devoted to the management of data generated by the working of a particular site (and not of a group of sites). Below, we will thus describe the use of GIS in the archaeological domain (large scale) and explain the distinction that we make with the term Information System, a term used in this paper to describe the work we are doing.

2.2 Geographic Information Systems

Geographic Information Systems have been developed to create relationships between data and to analyze spatial information recorded in databases. The principal application of a GIS is either heritage management (monitoring of known sites or identification of new ones) or explanatory framework (site catchments or viewshed analysis). The greatest number of GIS projects to date is toward landscape applications, driven by the needs of cultural resource management (van Leusen 1995) or predictive modeling. Many examples are cited by Richards who concludes: "There has been a lack of projects that have made effective use of GIS at the intra-site level; the projects on an Iberian cemetery (Quesada et al. 1995), Roman Iron Age sites in the Assendelvers Polders

(Meffert 1995), and the Romano-British settlement at Shepton Mallet (Biswell et al. 1995) are rare exceptions" (Richards 1998:338). Since then, some other projects of the type mentioned have obviously been carried out, but they are always less numerous than projects at higher levels, and what's more, the types of data treatments at a small scale can be very different from those done at a bigger scale.

For that reason, the project discussed here generalizes the notion of GIS in using the term Information System to describe our work. In fact, the data types that we manage are not only geographical data (maps, vectors) but also archaeological, historical, topographical, architectural, geological, environmental, textual, and more. An Information System could be defined as a combination of diverse types of data (recorded in databases) accessible through various interactive consultation systems. The quality of this system can be estimated by its capacity to present information in a useful way, as fast as possible. It is thus constructed, keeping in mind the need to acquire quickly the best information elements and to make these elements available for interpretive studies. Such a tool must permit the user to carry out a multidisciplinary synthesis of all resources of the database.

For archaeological data especially, the creation of an Information System can enable a user:

- to treat graphically several information types, derived from very different kinds of surveys, because a selective superposition could be a precious help for the interpretation;
- to combine elements selected in diverse graphs for carrying out visualizations in a synthesis plan;
- to present images and their connections with relevant texts from the database, to lead to a complex system in which the examination of texts and images would be possible simultaneously.

Especially in our project, the term management comprises the gathering of all the documents (photographs, maps, drawings, texts, etc.) already created or that will be done during the further exploitation of the site (models, virtual images), and the construction of relationships and links between them. The treatments of the information are necessarily combined with visualization systems that will permit one to see the results of the data extractions.

2.3 Visualization

Visualization of archaeological information is one of the most exciting ways in which computer technology can be employed in archaeology. The term visualization is used in reference to any exploration and reproduction of data by graphical means. The use of this technique allows visual interpretation of data through representation, modeling, and display of solids, surfaces, properties, or animation, what is rarely amenable to traditional paper publication (Richards 1998). It is constantly evolving. In the early 1990s, visualization meant three-dimensional (3D) modeling. Most visualization was developed for museum presentations. Reilly (1992) provides an excellent historical overview of early 3D modeling in archaeology: it is a little dated but basic utilizations are still the same. At the beginning there was principally solid-model reconstructions, which allows the archaeologists to visualize the aboveground appearance of sites that known only from their foundations. Virtual reconstruction is still a frequent intent for the construction of 3D models. More recently, surface models also have been applied in archaeology.

Most 3D models have been intended for heritage center and museums displays, and rarely are any of them available online via the Internet. An impressive and popular publication discussing visualizations of important international sites has been produced by (Forte and Siliotti 1997). Also, virtual reality with full immersion has great potential as a medium for interpretation and communication to the general public (Goodall et al. 2004; Tangelder and Veltkamp 2004). An example of Web-based visualization in Virtual Reality Modeling Language (VRML) that allows one to explore an archaeological landscape (large scale) is given in (Gillings and Goodrick 1996). There have also been applications of image processing and imaging technology in many areas of archaeology, such as classification, conservation, paleography, aerial photography, and satellite imaging.

Principal inconveniences of these types of 3D models for archaeology today are that factors (for museum displays notably) work toward the omission of archaeological complexity. They only serve for visualization needs and do not give any other information. For the first problem, the current techniques of surveying, such as photogrammetry and laser scanning, permit one to avoid losing complexity and create very accurate 3D models. Concerning the second difficulty, 3D models can now serve as research interfaces to access different kinds of information, notably in coupling them with Web procedures (scripts). Our project is producing interactive plans and models that work like a Web interface to obtain views of the database content. It is based on research of Drap (Drap and Grussenmeyer 2000; Drap et al. 2005), who has developed a system for integrating photogrammetric data and underwater archaeological content data.

2.4 Communication

Significant developments regarding communication currently have appeared with new forms of electronic publications. On this subject, Richards (1998:345) wrote: “Probably one of the safest predictions for the next millennium is that new forms of computer based publication will continue to revolutionize the dissemination of information; for some aspects of archaeological publication the book is now dead”. Electronic publication allows the distinction between traditional archive and hard copy report to be blurred, with supporting data made accessible (Ryan 1995). There are advantages through multimedia and accessibility of new forms of data, particularly drawings, plans, video, and photographs (Rahtz and Sinclair 1994; Smith 1992). In the late 1990s, some believed that CD-ROM publication represented the way forward, perhaps because it offers a model quite similar to traditional publication, while others (e.g., McAdam 1995) expressed doubts about the speed of adoption because of resistance from traditional publishers. We can say now that these doubts were well founded because there is not yet a great quantity of electronic publications in archaeology, especially available on the Internet. However, one of the best examples of online publication is *Internet Archaeology*, an international, peer-reviewed, electronic journal set up with funding from the United Kingdom's Higher Education and Further Funding Council (HEFCE) as part of their eLib (Electronic Libraries) program (Heyworth et al. 1995, 1996a, 1996b). This publication does not contain any material other than textual documents. In addition, there are a number of projects whose aim is (or was) to preserve a continually-updated archive of computer-readable material. In the United States, the Archaeological Data Archive Project (Eiteljorg 1995) sought care for data sets of value to archaeological research (this project is now aborted). In the United Kingdom, the Arts and Humanities Data Service has established an Archaeology Data Service to take responsibility for the long-term preservation and distribution of data to the archaeological community (Richards 1996).

According to Richards, “undoubtedly the major growth area of the second half of the 1990s has been that of archaeology on the Internet, particularly on the World Wide Web” (Richards 1998:347). This is even more true today; the Web provides a tremendous opportunity to link distributed resources and to make unpublished material widely available (remarkably uncommon material like detailed fieldwork data, quantities of photos and archive drawings, vectorial plans, and 3D models). The traditional division between publication and archive could thus be removed, even if there is still a major challenge to control the way in which the Internet is used (for the discoveries, quality controls, and copyrights). An example of an impressive project working on the Web is given by Stewart et al. (2004).

From our perspective, the term communication is more complete than just the publication of information. Representations adapted to museum displays will be done as well as interfaces permitting one to update the data directly from the 3D models (for instance) for the needs of site managers. This system works on the Internet to allow accessibility and simplicity for all users, and above all to be free from any software constraints. As a conclusion, Richards wrote: “in all areas of computer applications in archaeology, the discipline has been technology driven and software constrained. Rarely has the use of computers in archaeology been led by archaeological theory, although in specific fields, such as GIS, it can be demonstrated that computers have advanced archaeological knowledge” (Richards 1998:348). Thus, we hope the Information System we are developing will also serve archaeological knowledge in proposing another type of communication and sharing of information coming from individual archaeological sites.

3 First Implementation of a Web Information System Dedicated to Archaeological Intra-site Features Documentation

The place of interest that spurred the development of our system is the medieval castle of Vianden, located in northeast Luxembourg. This archaeological site has a very long (since the 4th century) and interesting history, during which a lot of documents have been created and stored. These documents are complex and heterogeneous, so it is necessary to record metadata about them and to propose different types of interfaces to query the metadata and data.

We propose a description of the data in textual interfaces along with images, and dynamic links to these data through interactive 2D and 3D representations. All the data are described in XML, the standard language of the World Wide Web Consortium (W3C), for the portability of the system and to facilitate information exchanges. The 2D images, photos, and vectors are generated in Scalable Vector Graphics (SVG), while 3D models are generated in Extensible 3D (X3D).

The aim of this Information System is to assist the digital archiving of the documents, their inquiry, and their processing by everyone, both professionals (archaeologists, surveyor, architects, etc.) and the general public. Different types of access to the data are available depending on the user of the system. The documents concerned are:

- paper plans and drawings that have been digitized;

- digital photographs or ancient photographs scanned;
- texts scanned from ancient or recent books;
- 2D graphs (generated, for instance, from plans);
- 3D models created from documents (historical reconstruction) or obtained by surveying techniques (topography, photogrammetry, or laser scanning).

The two main query forms in the system are on the historical periods of the castle and on the most important geographical places, which are concerns archaeologists, who need to position their features in space and in time. The home page of the Web Information System (for the case of the Vianden Castle) is illustrated in Figure 1.

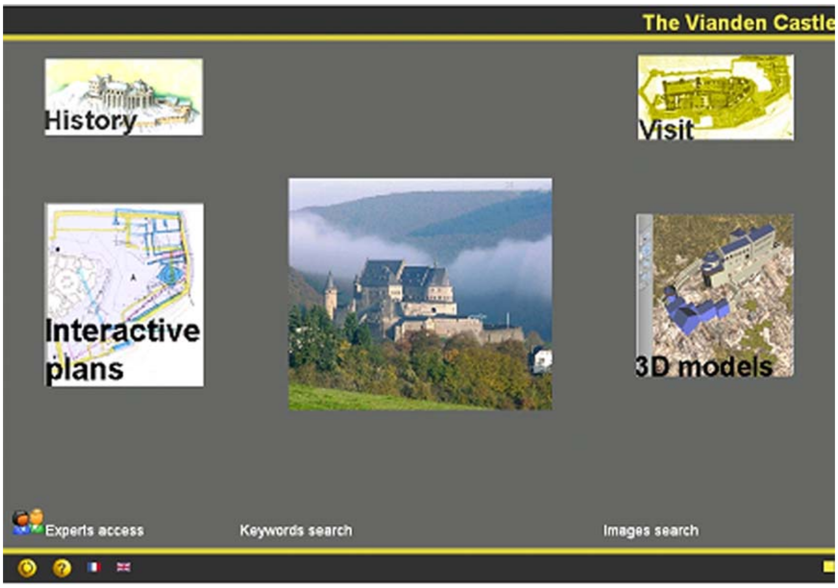

Figure 1. Home page of the web Information System developed. Example of the Vianden Castle.

3.1 The Different Data Types in the System

On the website for Vianden Castle, Gaby Frantzen-Heger (2005) wrote the following:

> Vianden Castle was constructed between the 11th and 14th centuries on the foundations of a Roman ‘castellum’ and a Carolingian refuge. It is one of the largest and most beautiful feudal residences of the Romanesque and gothic periods in Europe. Until the beginning of the 15th century it was the seat of the influential counts of Vianden who could boast their close connections to the Royal Family of France and the German imperial court. Henry I of Vianden (1220-1250) is known as ‘the Sun Count’ for it is during his tenure that the holdings, lifestyle and influence of the House of Vianden reached its zenith. His ancestors were influential in the Ardennes, Eifel and Luxembourg regions for hundreds of years. […] The main construction parts of the castle which are preserved today, in particular the chapel and the small and large palaces, originate from the end of the 12th and the first half of the 13th century. The ‘Quartier de Juliers’ on the western side of the large palace (no longer existing today), originates from the beginning of the 14th century**.** The House of Nassau was only constructed at the beginning of the 17th century. In 1820, under the reign of King William I of Holland, the castle was sold piece by piece, and as a result, it fell into a state of ruin. It was a pile of rubble until the family of the Grand Duke of Luxembourg transferred it to State ownership in 1977. Since restored to its former glory, the castle now ranks as a monument of not only regional, but European importance.

This small chronological account illustrates that the castle has a rich and long history, and that it is important to be able to proceed to temporal analyses of it. Ten main periods emerge from the study of the castle history. The *period* is then the first data type in our system, and it is also a query unit for which the other data are going to reference. Each period has a descriptive form related to it. The browsing interface corresponding to a period is shown in Figure 2.

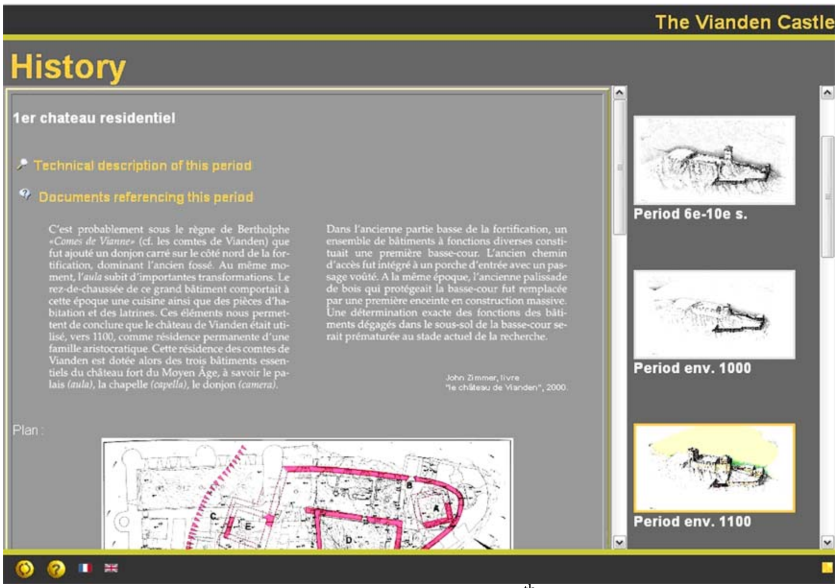

Figure 2. Browsing interface corresponding to the 4th building period of the castle.

For each *period*, the Web page has the same structure: a small text describing the events that occurred during it, a plan of the castle foundations, a drawing showing a reconstitution of the castle, and a screenshot of the 3D model created for this period with an access link to it. These Web pages are generated on the fly in PHP for recovering the information recorded in the database for each period.

The second principal query unit is the spatial level, the data type that we have called *place*. In fact, it is possible to distinguish several remarkable places in and around the castle. They correspond to the existing rooms of the castle, but also to the key places that are partially or fully destroyed, and to the exterior elements. The choice of these places has been made by order of importance (notably in size), and thus we have also created the data type *sub-place* corresponding to a part of a composite place, if this part presents a particular interest and if some documents specifically refer to it. The menu for the virtual visit of the castle is presented in Figure 3.

Figure 3. Menu for the virtual visit of the castle places. Example of the exterior places.

Like for the data type *period*, for each *place* the pages are generated on the fly according to the data found in the database. For each level of the castle, an interactive SVG plan allowing direct access to the data corresponding to the clicked places has been created in the free software Inkscape. Likewise, information on the places are available through 3D models. Thus, there are different access possibilities to reach the data recorded in the database.

The other data types that have been integrated into our system and therefore managed by it are:

- different sorts of plans that have been digitized (*axonometries*, *maps*, *sections*, *plans*, *elevations*, *excavation profiles* and *plans*),

- digital *photos* or ancient photos digitized,
- scanned *drawings*,
- scanned *texts* (of all epochs),
- *vectorial plans* (generated in SVG),
- *3D models* (generated in X3D).

These types of documents are considered as data types in the system because they constitute the main source of documentation about the castle. They are accessible by queries through search tools and through the interactive 2D and 3D representations that have been generated (thanks to surveys, notably). To be able to formulate queries on the *period*s and on the *place*s, each of these data types has a list of periods and places to which it refers. To be managed by the Information System, all these data have to been recorded and classified in XML for standardization, and in a MySQL database for queries.

3.2 The XML Database

XML is a meta-language to structure information. XML uses tags (keywords in angle brackets with additional attributes) to enclose content. Compared with HTML, the denotation of the tags is not defined and will be interpreted afterwards by the application. XML files are plain text files. Rendering XML files requires other technologies (parsing). XML documents are starting with a prologue, followed by the root element. For example, for a data type *place*, the prologue is the following:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<?xml-stylesheet type="text/xsl" href="arbreForm.xsl"?>
<place>

<!-- content of the document -->

</place>
```

An element and its sub-elements will be represented in the tree structure by nodes. The element itself consists of a start-tag, the content and an end-tag. Attributes will be added into the start-tag. A Web browser displays the tree structure of the document. By simply clicking the symbols (+, -), the nodes can be closed or opened, as shown in Figure 4.

The style on the Web page of the root element *place* is defined in an external Extensible Stylesheet Language (XSL) document (in the example `arbreForm.xsl`). The XSL provides transformation from XML into another, more readable format. An XSL processor can be applied by the Web browser or, as an alternative, server sided by the application. An off-line transformation results in a HTML document to be stored on the server. An external XSL file must be referenced in the prologue using the statement quoted above. HTML tags must be combined with XSL statements to obtain the final form of the object (Figure 4).

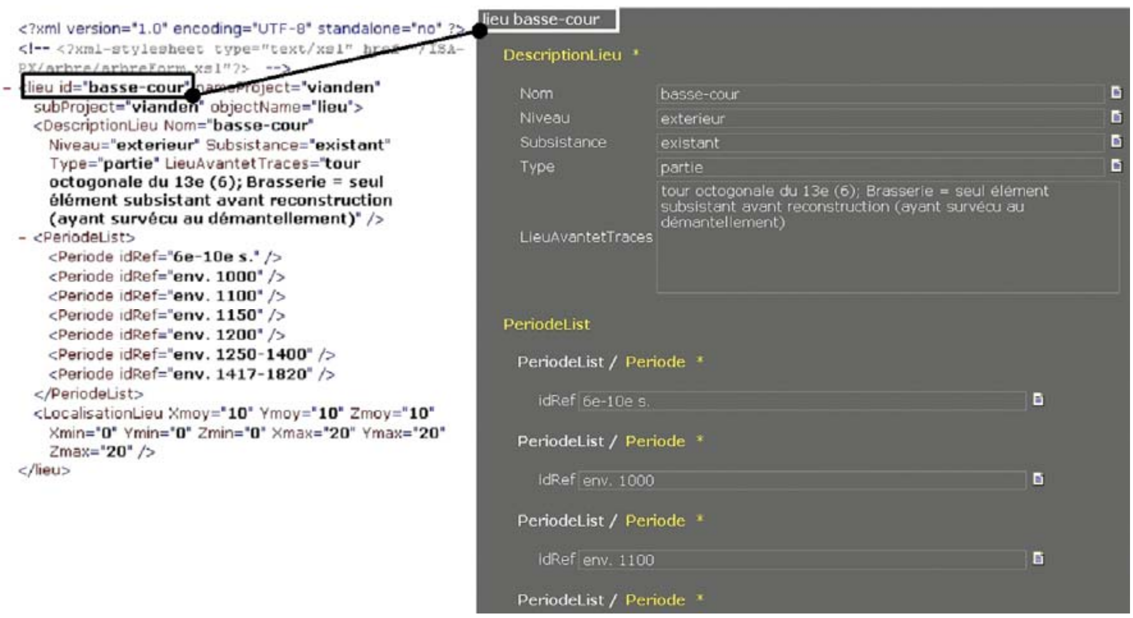

Figure 4. Tree structure of a data in XML (left) and
HTML form of the XML file thanks to an external XSL document (right).

Instancing process. At the beginning, an example of each data type has been entered into the database under the form of a simple XML document generated in a XML designer. After that, the type of each identified object (plan, text, drawing, 3D model, etc.) is memorized in the system and the documents can be recorded by fulfilling a data entry form created thanks to a PHP program. The recognition of the document type and the use of the XML data are possible thanks to a parser that analyses and validates the file structure. Events are the occurrences of tags and content. Then, when we enter the description of a new document in the data entry form, after the parsing of this file, the system produces for each object an XML file with the relevant data. A corpus with all the values of all the attributes is also available without any action of the user. At the same time, a MySQL database is created and automatically filled. Figure 4 gives an example of data access through the Information System and directly through the MySQL database.

Moreover, the same data (for example the descriptive form of the 4th period, as in Figure 5) can be accessed through the period menu (see Figure 2): if we choose the item *Period env. 1100*, we have access to some images of the castle during this period and, also, to the direct link with the descriptive form of the period along with the form that presents all the documents that have a relation to this period. As we can see, the system allows users to access the data in very different ways, which gives the users, navigation flexibility. Additionally, these are not all of the access possibilities: some 2D and 3D interactive plans and models have been generated to permit another access type (more spatial) to the data.

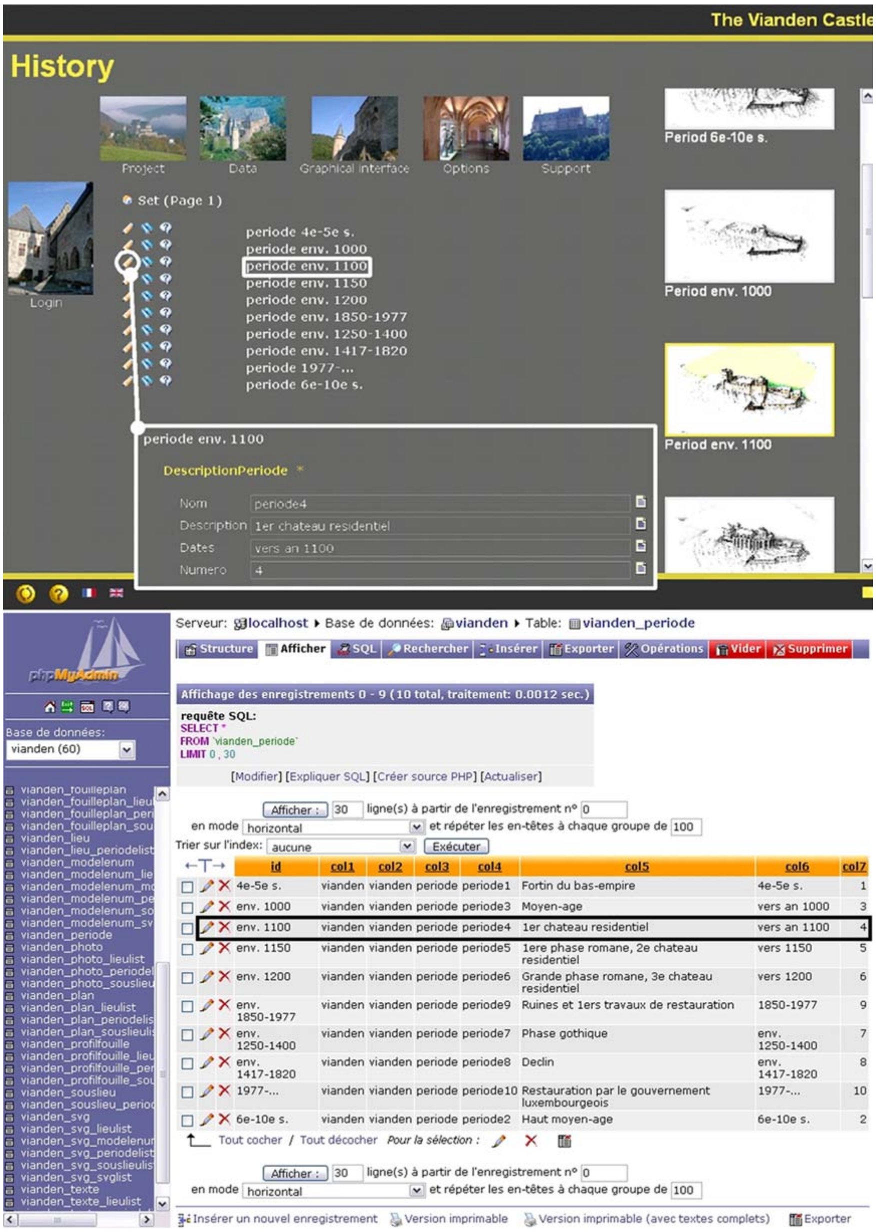

Figure 5. Different types of access to the data: interpreted XML (up) and MySQL database (down).

3.3 The SVG Interface

Scalable Vector Graphics (SVG) is the XML formulation of 2D vector graphics. It was therefore chosen because of its multi-platform capability and full compliance with XML specifications. It includes drawings of vector data, displaying of image data, interaction, and animation. Structure and appearance of graphic elements are separated by using stylesheets. Applying an SVG viewer as a plug-in for the Web browser enables zooming and panning in the graphic area. Furthermore, sophisticated design possibilities such as pattern filling, shading, insertion of symbols, and others are provided by SVG.

The above potentialities of SVG were employed by building a representation that gives quick access to the dataset by means of templates defined by the user: archaeological templates, photographic templates, typological templates, etc. The PHP interpreter allows access to the file system of the server and a JavaScript program permits the interactivity between the SVG graphic and the Information System. By clicking on different zones (corresponding to the data type *place*) defined in the SVG drawing, we access the corresponding form showing the elements that refer to the clicked zone.

Figure 6 gives an example of an SVG interface created from a scanned image and on which interactions zones have been drawn. It corresponds to the plan of the castle's farmyard as it is today. More particularly, it can be seen from the search of documents concerning the *sub-place* octagonal tower (*tour octogonale*), which is included in the composite *place* farmyard (*basse-cour*). When clicking on the geographic place corresponding to the ruins of this tower, we access all the documents making reference to it or referenced by it. For instance, we can see that an object *photo* corresponds to it, and when we click on the item permitting access to the descriptive form of this photo, we see the metadata recorded in the database, and we can click on the miniature to see the original photo. In this case, this interactive plan has been opened through the Visit menu and the item *place basse-cour*, but all the SVG interfaces can be naturally accessed through the *Interactive plans* menu of the home page (see Figure 1).

The 2D interfaces are useful to complete the 3D interfaces that will be explained below because archaeologists (notably) are more used to working with 2D representations than with 3D models. So, we have created 2D interactive graphics to allow another type of information navigation. However, 3D offers more possibilities than 2D, so we have developed interaction means for the 3D models that work the same way as the 2D graphics explained here.

3.4 The X3D Interface

3D graphics data for the Web in VRML are updated to XML, predicted as Extensible 3D X3D. The VRML code has just to be rewritten with XML conventions and descriptive elements to convert it to X3D format. A lot of viewers can be used for VRML and X3D in stand-alone mode or as plug-ins for Web browsers.

The navigation through the 3D model works in the same way as in the 2D SVG interface, with all the additional possibilities offered by 3D. The PHP interpreter, scripts in JavaScript, and VRMLScript with “routes” are also used for communication between the database server and the 3D model for access to the data that refers to the clicked element. Currently the access to information is only unidirectional. When we click on the model, we obtain the documents referencing the place clicked. It is not possible at the moment to have a particular point of view on a place in the model chosen beforehand. Our next research effort will be conducted to offer further access possibilities to the data and to give more interactivity.

The 3D models included in the Information System have been produced from historical documents (for the models of the past phases of the castle) or from surveys (notably through laser scanning). The modeling can be done in any software permitting export in VRML or X3D (for instance Maya). Figure 7 gives an example of a 3D model coming from the laser scanning of the farmyard of the castle, which was done a few years ago by the ArcTron society from Germany. This model corresponds to the interactive plan presented in section 3.3, above. The same interactions are possible, along with the opportunity to turn the model, to zoom in deeply or to see elevation data, for instance details of a wall with a staircase (former rampart walk) that had no previous interest from the 2D representation.

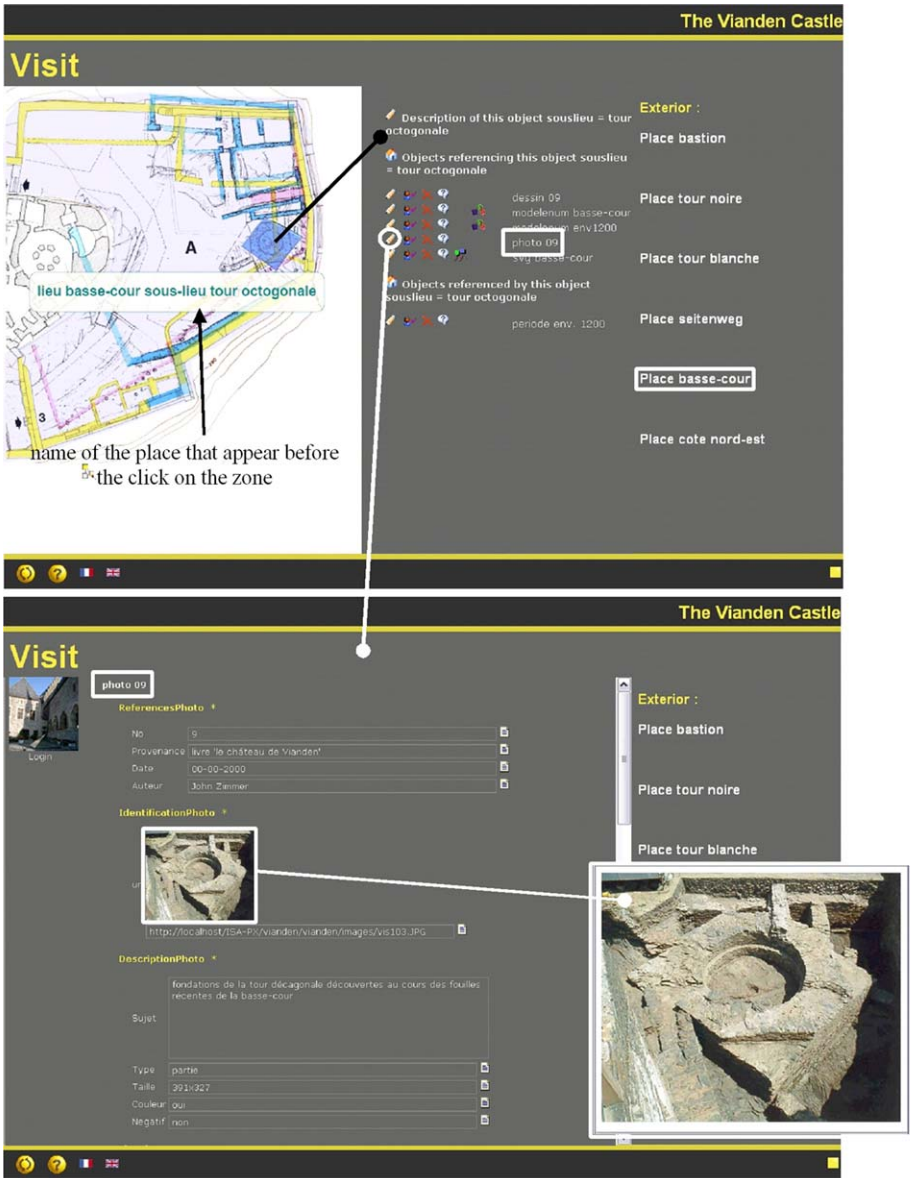

Figure 6. Interactive SVG interface and correlated documents that can be directly open afterwards.

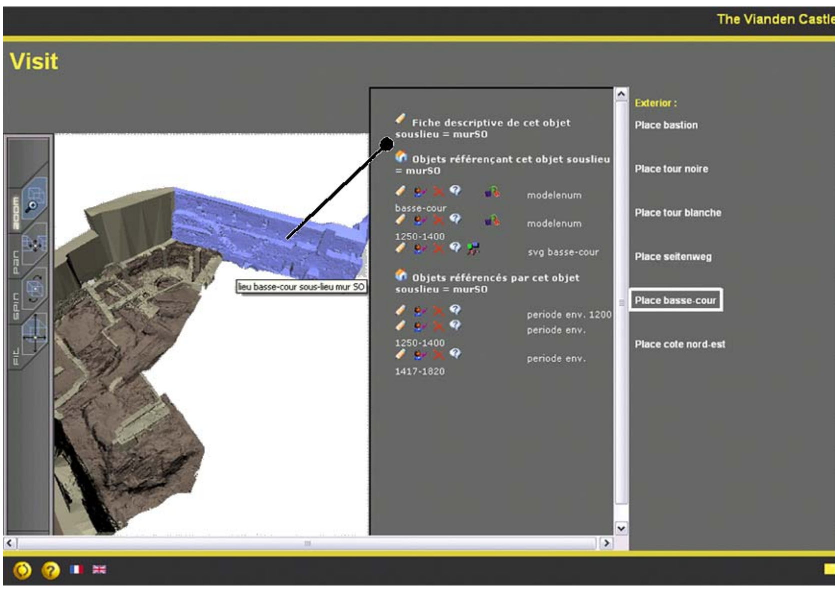

Figure 7. Interactive X3D interface allowing access to data referencing and being referenced by the place clicked.

3.5 Updating, Revising, and Correcting the Data

To look at the data is the first step in the analysis of a dataset. To go further, the archaeologist (or any expert involved) needs to edit the data. A login process allows the user of the Information System to be identified in order to be able to add data or to modify the facts recorded. This modification is possible in three ways: the update, the revision, and the correction of the data and metadata.

The update is the process that permits one to manage the evolution of the site (construction, destruction of artefacts). Most of the time, it consists of adding new data (drawings, texts, graphs, and so on) and in modifying metadata about the already recorded objects. For instance, if a building has been destroyed, the old plans stay in the database, but their metadata have to be modified to indicate that the building appearing on the plan does not exist anymore.

To update the data and the metadata recorded in the database:

- the metadata corpus can be used to correct some basic errors (misspelling or simple inconsistencies);
- through the graphic interfaces in SVG or VRML, the expert user can directly modify the metadata of the selected data;
- through different types of search engines (by data type, by location, by epoch), the user can access the data and edit it for modifications;
- a particular item of the Information System permits the addition of new data.

For the insertion of new data, there are two cases. If the data type is already known in the system, the user has just to fill out a data entry form to add a new occurrence of this data. In the other case, if the data type does not exist yet, the user has to create it and afterwards he can choose the metadata to record (according to a standard like the CIDOC-CRM, for example) for the type of data considered.

The revision is another procedure that has to be done if the knowledge of the archaeologist about the site has evolved over time. For instance, if the occupancy of a building has changed, or if a new finding made during a recent excavation deeply modifies the former ideas of the archaeologist about the age or the use of the site. In this case, it is necessary to revise the system, which can mean changes in the data conceptual model (the relations between the data can vary as well as their attributes). The expert user will then modify the tree structure of the dataset describing the data model. The revision may also concern the maps and the models of the diverse parts of the site. Indeed, if, for instance, the architectural organization of archaeological entities changes during the working of the site, it is necessary to modify accordingly the 3D models and the maps already recorded and interfaced in the system. Finally, the correction is principally the rectification of errors that can exist or appear in the database (data recorded two times with different names, bad links between the tables, and so forth).

4 Conclusion and Future Work

The first part of this paper highlights the increasing role of information technologies, particularly of databases, Information Systems, and communication means, in the domain of archaeology. Notably on the scale of an archaeological site, there are, currently, few completed works on this subject, and there is a recognized need in the domain for effective IT tools. The paper then, a proposal for a Web-based, archaeological Information System has been created to search solutions to help archaeologists in their efforts at an intra-site level while avoiding the problems that can come from software-driven applications. The key feature of our Information System is that it allows the combining of a representation of site architecture with a database serving as a tool for the analysis of its units.

In comparison to GIS, the Information System developed allows users to manage all types of documentary data related to an archaeological site or monument. We are not limited to large-scale spatial data, as we connect all the data types based on places and periods that are linked to the data. Thus, the user can do different kinds of spatiotemporal searches on the data, especially in three dimensions, which is rarely amenable in a traditional GIS.

A full XML choice for textual and graphical representation permits relevant interactions between the diverse types of data managed by the system. The use of 2D vector graphics and 3D models as user-interfaces to the data link purely documentary data (references, plans made during the excavation, photographs, texts, elevations, etc.) to geometric representations of the object. We connect very different types of data to emphasize new research possibilities, and new information exchanges between many sites of the same epoch, for example, can enable one to draw conclusions by crosschecking (a standardized recording system is of the utmost importance for this). Finally, the data available through the Internet and the XML formalism allow us to update and revise data in their 2D and 3D representations, and of communicating the data in an innovative and interactive way. Figure 8 sums up the computer behavior of the system we are developing.

For the continuation of our work, we will concentrate on the query possibilities in the system (search by keywords and images), as well as on the development of bidirectional links between the 2D and 3D representations and the other documents. Readability and comprehensibility of the Web Information System will also be improved in order to simplify the navigation for all types of user.

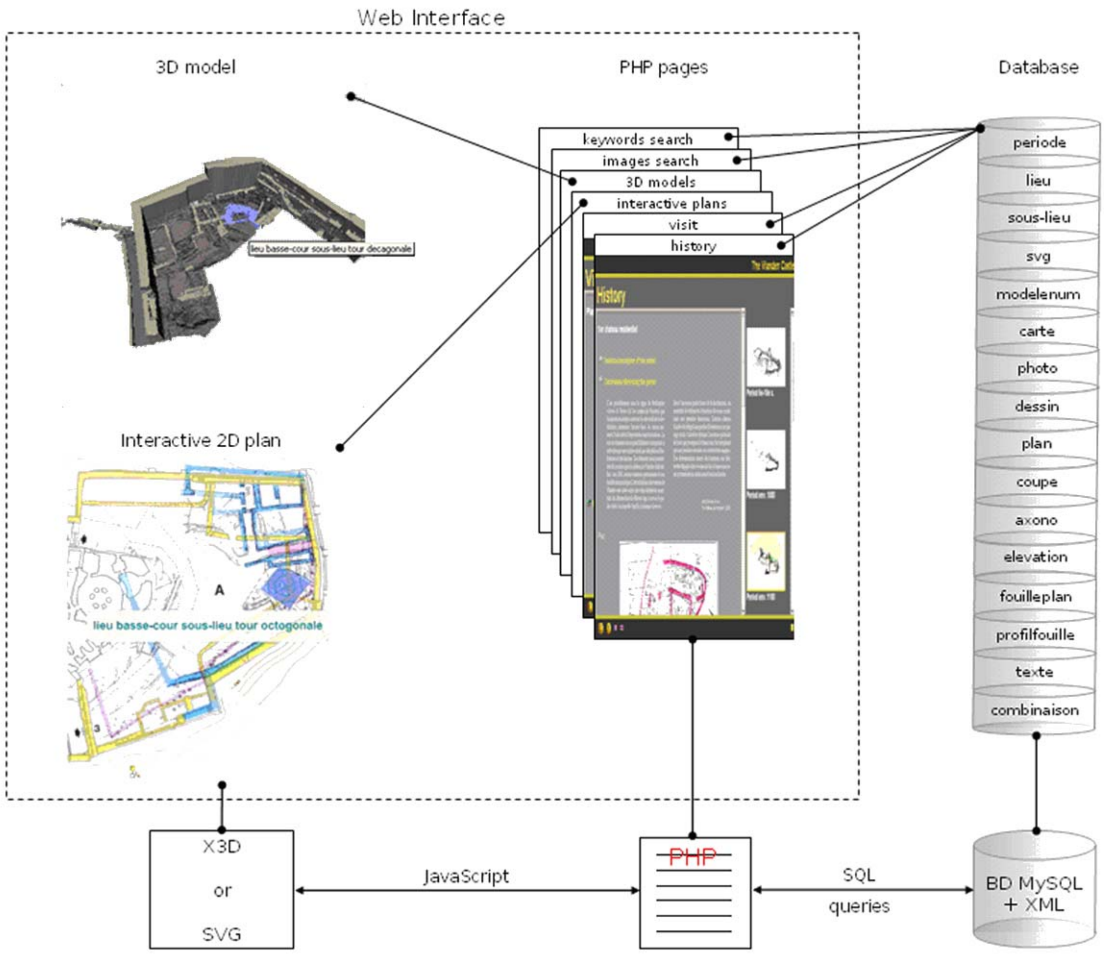

Figure 8. Schema representing the computer behavior of the archaeological Information System carried out.

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